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Analysis of Rural Road Geometry, it's Consistency and Safety through Alignment Index in Kaski,Nepal

Prakash Baral[1]

[1]*Assistant Professor, Civil Engineering, Pokhara University, Pokhara, Nepal*

Abstract

Road accidents are major problem these days in rural road of Kaski. Driver, vehicle, road condition as well as weather conditions are mostly liable to cause such circumstances. Road geometry and its consistency are basically measure through operating speed, alignment index, vehicle- stability and driver workload respectively. Safety is burning issues in the field of transportation engineering which can be address only due to consistent design of rural road alignment. This study tries to quantify the influence of alignment index on road safety using operating speed and design speed to predict the crash rate for evaluation of consistency in Methlang-Gyarjati rural road, Kaski. In this paper crash rate prediction model were developed which can be utilized to measure consistency using alignment indices(Average curve length and tangent length) on two lane undivided rural road for a mixed traffic flow having similar type of topography and geometric characteristics.

Key words: Alignment indices, Safety, Crash rate, Roadway geometry, Rural road

1.INTRODUCTION

Vehicle accident occurs frequently in the hilly area of Nepal where vehicle plunged down to several meters from the road surface causing a lot of fatalities and injuries every year. High speed of vehicles, steering or brake failures, unfamiliar and intoxicated drivers, long duty hours of driver continuously, poor condition of vehicles, muddy and slippery roads, haphazard overtaking, poor maintenance, loaded cargo, negligence of traffic rules and signs are major cause behind this scenario.

In Nepal, vehicle accident was 8406 in FY 2013/14 and the number increased by 08.79 percent and reached to 9145 in FY 2014/15.Likewise,it increased to 10013 in FY 2015/16 and rose by 09.49 percentage. Beside these facts, number of vehicles accident increased by 01.65 percentage only and reached to 10178 vehicles in FY 2016/17.Frequent vehicle accident had occurred in hilly areas where vehicle fall down up to 500m from the road with tremendous increase in fatalities. Human error, poor infrastructure, geological conditions are major aspect causing road accidents.(Bhagat,S.K.,2017) Geometric design inconsistencies are also a vital aspect to cause accidents which are becoming serious issues these days in Nepal.

According to the report by WHO, the number of annual road traffic deaths, globally has reached 1.35 million and approximately causes up-to 50 million more injuries. Different countries are trying to adopt different measures to minimize it which varies significantly. With rate of 27.5 deaths per 1,00,000 population, the risk is 3 times higher in low-income countries than in high income countries where the average rate is 8.3 deaths per 1,00,000 population. This reflect that road traffic death is disproportionately high among low-income group as seen from the size of their population and number of motor vehicles point of view.(Gemechu Shiferaw et.al,2021)

Geometric design consistency is an important measure in designing a road as well as an important tool to evaluate safety. Design consistency evaluation is gaining popularity these days due to increase in crash rate. Various methods can be utilized to check the consistency of roadway geometry. Operating speed, alignment index, vehicle stability and driver workload are mostly common in operation regarding this aspect.

Road design without safety measures is meaningless. The major objective of road transport is to provide easy, safe and efficient service to the road users which could only be achieved through consistent design. On the other hand, if there is inconsistency in roadway geometry then there will be abrupt changes in speed and workload of the driver. This result in critical driving manoeuvre which leads to increase in the probability of accidents.

Kaski district rural roads cannot be kept aside regarding to question in safety. Road crashes level is increasing over time along with the growth in the number of vehicles, the population, the road network and the vehicles kilometres driven.

In the aspect of developing countries like Nepal very few studies have been conducted in this regard. This paper preliminary analysed the geometric design,it's consistency and safety on the alignment of Methlang- Gyarjati rural road of Kaski on the basis of alignment index and crash rate which can be utilized to remove shortcomings in road safety standard, design and implementation of policies and safe transportation infrastructure in rural roads of Kaski.

1.1 Statement of the problem:

Safety issue is major aspect to be taken into consideration especially in rural road of Kaski district. Every year the rate of fatalities is increasing with a huge loss of life and property. Inadequacy in road length, shoulder width, sharp curve, large speed variation, lack of proper structure, inadequacy of drainage etc. are major factors contributing to high rate of crashes in such rural roads.

1.2 Objectives:

The major objectives under the study are:

- To analyse the rural road geometry and its consistency based on alignment indices.
- To develop a safety model for analysis of safety.

1.3 Significance of the study:

This study will assist planner, designer to maintain consistency in roadway geometry. The safety model develops in this study will help to reduce accident in long run. It also helps to reform NRRS (Nepal Rural Road Standard) as per necessity which assist in consistent roadway geometry design. It finally proves to be a helpful tool to evaluate safety which is necessary for socio-economic development of a country.

2. Literature Review:

Design consistency has been evaluated and studied widely in the past century. In the early part of the 1980's researchers found poor design consistency performance caused higher driver workload.(Article…

The inconsistent design was summarized as "a geometric feature or combination of adjacent features that have such unexpectedly high driver workload that motorist may be surprised and possibly drive in an unsafe manner."(Messer, 1980). In terms of the design consistency concept,"Design consistency is the conformance of a highway geometric and operational features with driver expectancy." Consistent roadway geometry allows the driver to accurately predict the roadways path with little cognitive effort, in turn leaving much of driver's mental capacity to be devoted to obstacle avoidance or navigation. (Wooldridge et al., 2003)

Fitzpatrick et al. defined alignment indices as "quantitative measures of the general character of a roadway segments alignment. "In terms of increasing the geometric inconsistencies alignment indices change in relation to the high rate or large increase of different segments of the roadway. (Fitzpatrick et al., 2000)

Basically, horizontal curves are more dangerous which possesses higher crash rate than straight sections of similar length and traffic composition. The increase in crash rate becomes particularly significant at radii below 200m. (Mohammed Hameed, 2013)

Traffic volume on the curve and mix traffic, curve features, cross-sectional curve elements, curve section roadside hazard features(clear slope, rigidity and type of obstacle),stopping sight distance at curve approach, friction, distance of adjacent curves too influence the safety at horizontal curve sections.(Ali Aram,2010)

Polus and Dagan proposed alignment indices which are based on different geometric characteristics in curve roadway sections. From their preliminary evaluation it was suggested that such indices hold promise a measure of consistency. (A.Polus et.al., 1987).High rate of change in alignment indices over some length of roadway lead to geometric inconsistencies.

German uses a horizontal alignment index as alignment severity.(StraBen Richtlinien et.al.,1984)

Likewise, in various study, though different element of the roadway sections including tangent length and major accident record have been used to predict a model which lack consideration of speed. So, this study propose to develop a simple model based on crash rate(CR) as given by earlier established model where crashes on the major, minor fatalities are not classified as in the earlier study.

3. Methodology:

3.1 Study area:

The study area (Methlang-Gyarjati road section) lies at $28^0$14'27"N latitude and $83^0$58'00"E Longitude. It has an elevation of 895m from the mean sea level. This road connect Baglung highway with Sarangkot VDC. It is selected for study on the basis of variation in the geometric features which was observed during preliminary survey.

3.2Data Collection:

Data related to horizontal road alignment are collected through field survey for preliminary test.

Table-1 Summary of Geometric details at Curves

S.no	Geometric element	C_1	C_2	C_3
1	Radius(R)	38.85	24.05	73.49
2	Curve length(C_L)	14.90	8.81	26.92
3	Deflection angle(Δ)	22^0	21^0	21^0
4	Pavement width(P_w)	4.58	4.71	3.68
5	Shoulder width(S_w)	0.39	0.36	0.12
6	Tangent length(T_L)	2.89	4.45	13.62
7	Crash Rate(CR)	2.31	2.12	2.11

Fatalities and crashes are measures of inconsistency in rural road. The data for the crash rate is calculated based on the predetermined model

$CR=0.0041(v_{85}-v_d)^2+(V85-Vd)+3.4325$

Where, operating speed of the vehicles are collected through mobile smart sensors in the field.

3.3 Data Analysis:

Most of the alignment indices require for the research are identified and included in current design studies. Study stretches include a smaller section of road with three horizontal curves which are utilized for finding horizontal alignment indices. (Table -2)

Table- 2 Horizontal alignment indices:

Average Radius	ΣR/N
Average Tangent length	ΣTL/N
Average radius to road length	AR/L
Average curve length to tangent length	AV.(CL/TL)
Tangent length to average tangent length	TL:AV.TL

Different scatter plots are made to obtain the relationship between crash rate and various alignment indices parameters. The scatter plots are then utilize to develop a safety models.. From the preliminary analysis, it is clear that AV. (CL/TL) (Figure.1) shows positive relationship with crash rate whereas, Av. CL:RL(Figure.2), AV.R/L(Figure.3) and TL/AV.TL(Figure. 4), shows inverse relationship to crash rate(CR).The summary statistics of alignment indices(Table -3) shows significance of the study.

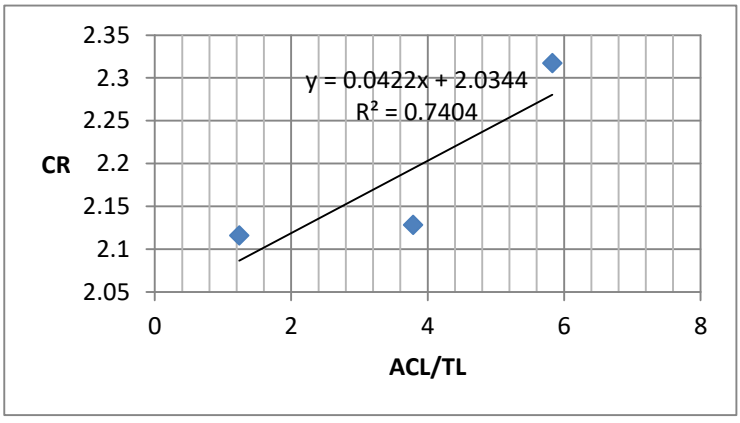

Figure -1: Plot of CR & AC/TL

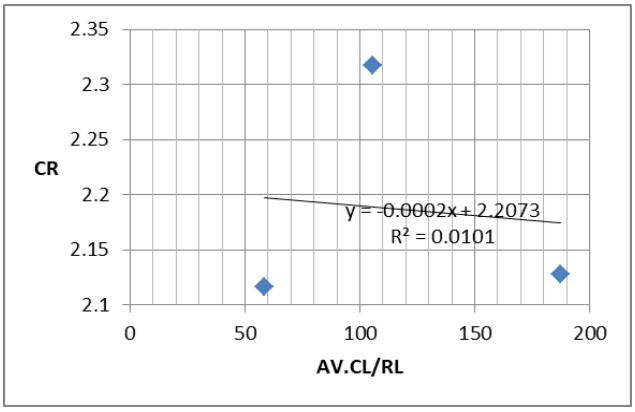

Figure -2: Plot of CR & AV.CL/RL

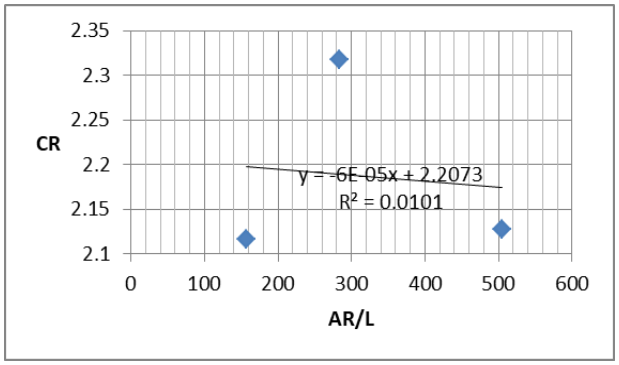

Figure -3: Plot of CR & AR/L

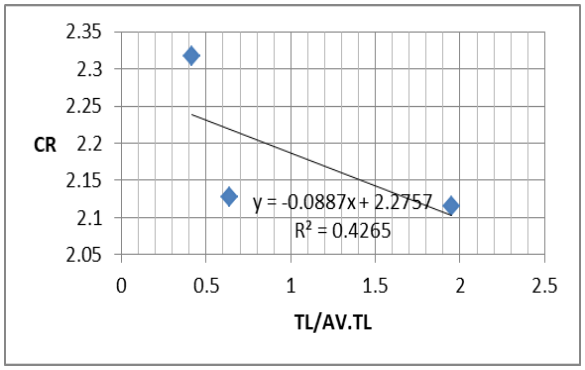

Figure -4: Plot of CR & TL/AV.TL

3.4 Model Formulation:

It has been observed that horizontal alignment indices which comprise a proportion between average curve length to tangent length (Table -2) is the most influencing factors to crash rate with(R2=0.7404, RMSE=0.046) and predicted crash rate as (CR=0.042AV.CL/TL+2.034) respectively.

(Figure.1)than other alignment indices in the present study. It shows that with increase in the ratio of average curve length to tangent length there is increase in crash rate which shows inconsistency in road alignment of Kaski.

Regarding to other indices the case is different where increase in alignment indices there is decrease in crash rate which ensure consistencyand safety. The safety evaluation model

(Table - 4) shows variation in indices along horizontal curve section which determine inconsistencies along the rural road alignment of study area that are prone to accident leading declination in safety.

Table -4 Safety evaluation model:

Alignment index	Min^m	Max^m	Av.	S.D.
(CL/TL)	1.97	5.15	3.03	4.65
CR:AV.TL	3.44	10.52	6.50	1.77
CR:(CL/RL)	242.81	267.22	254.48	6.10
(CR/TL):AV.TL	37.68	94.75	56.86	14.2

4. Discussion:

In previous study (Jeena Jhony et.al, 2019), average curve length, average tangent length was found to be the most influencing factor which also prevail in thisstudy, though predetermined crash rate model were utilized in this study instead of number of accident data collected.

Similarly, as per evaluation made for two lane rural highway for Indian condition average curve length was found to be the good alignment index. (Anitha Jacob et.al,2018).The validity of the result further can be achieved through R2=0.7404 andRMSE value of 0.04699 which is obtained from the analysis.

Further, the predetermined model of crash rate Which is used in this paper consider operating speed as well as design speed which are vital in analysis of rural road geometric design consistency which assist to determine the condition of safety inMethlang-Gyarjati rural road,Kaski.

5. CONCLUSIONS

- Ratio of curve length to tangent length and average radius to roadway length was found to be the most influencing variable with the crash rate on horizontal curves of rural road of Kaski.
- Evaluation of horizontal curve consistency based on crash rate and safety model for selected road section were obtained.
- Highly influencing variables over a study section must be considered to obtain geometric consistency to maintain safety in rural roads of Kaski.
- The result so obtained from the preliminary analysis of this study may be taken into consideration for vertical alignment. Beside this other factors can also be utilize for analysis of road consistency and safety in future.

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